IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Serial No. 09/973,685
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Constantin Stancu et al.

Group 2834

MAXIMUM TORQUE-PER-AMPERE
CONTROL OF A SATURATED SURF
ACE-MOUNTED PERMANENT
MAGNETMACHINE

Examiner David W. Scheuermann

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Mail Stop Appeal Brief-Patents
Commissioner for Patents
PO Box 1450
Alexandria VA 22313-1450

Sir:

BRIEF FOR APPELLANT GENERAL MOTORS

General Motors is filing this Brief to support the Appeal of Claims 1-6, and 8-12 which the Office Action dated January 10, 2005, finally rejected. Please charge the fee required by this Brief and any other fees as well as one-month extension fee, which may be due to Deposit Account No. 07-0960.

I hereby certify that this correspondence is being transmitted by facsimile on the date shown below to the United States Patent and Trademark Office at 571-273-0042.

On December 16, 2005. Signature: Stephanie Harbin
Stephanie Harbin

I. REAL PARTY IN INTEREST

In this appeal the real party of interest is the assignee, General Motors Corporation.

II. RELATED APPEALS AND INTERFERENCES

There are no related appeals and interferences.

III. STATUS OF CLAIMS

Claims 1-6, and 8-12 are under final rejection and are on appeal.

IV. STATUS OF AMENDMENTS

General Motors has filed no amendments since the final rejection of January 10, 2005.

V. SUMMARY OF CLAIMED SUBJECT MATTER

Below is a Brief Summary discussing the objective features and advantages of the invention. Following the Brief Summary is a detailed summary complying with 37 C.F.R. 1.192(c)(3).

A. BRIEF SUMMARY

The present invention is a method and apparatus for increasing the torque of a surface-mounted permanent magnet machine or motor by using saturation-induced reluctance torque. At high stator current levels, when the effects of magnetizing saturation cannot be neglected, the two magnetizing inductances (L_d and L_q) in a vector control scheme are not equal, and additional torque can be obtained from the motor if the d-axis current is controlled to an optimal, non-zero value. The angle β is shown in Figure 1 of the present application as the vector component of the d and q axis currents. By varying the angle β, different current setpoints in the control scheme of the present invention may be used to control the electromagnetic torque of the motor, as L_d and L_q are not zero at relatively high stator current levels.

B. DETAILED SUMMARY

Claim 1 recites an electric motor control system (page 2, lines 7-9 and Figure 3) comprising: a stator for producing a magnetic field (page 3, lines 25-27 and Figure 2, reference number 12); a surface mount permanent magnet rotor rotated by said magnetic field (page 3, lines 25 through page 4, line 2 and Figure 2, reference number 14 and 18); a motor shaft coupled to said rotor (page 3, line 25 through page 4, line 2 and Figure 2, reference numbers 14 and 18); power electronics for controlling said magnetic field in said stator (page 4, lines 21-26 and Figure 3, reference number 22); wherein said power electronics controls the q-axis and d-axis current components for the electric motor (page 4, lines 3-28 and Figure 3, reference number 22); and a controller controlling said power electronics, said controller including a control block to control the d-axis current as a function of the angle β when said permanent magnet rotor is in magnetic saturation (page 4, lines 3-28 and Figure 3, reference numbers 22 and 24).

Claim 2 recites the electric motor control system of Claim 1 wherein said stator includes current carrying coils to generate said magnetic field (page 3, lines 25-27 and Figure 2, reference number 12).

Claim 3 recites the electric motor control system of Claim 1 wherein said surface mount permanent magnet rotor includes rare earth magnets (page 4, lines 1-2 and Figure 2, reference number 18).

Claim 4 recites the electric motor control system of Claim 1 wherein said power electronics comprises a voltage source inverter (page 4, lines 5-10 and Figure 3, reference number 22).

Claim 5 recites the electric motor control system of Claim 1 wherein said permanent magnet rotor exhibits non-linear behavior when said d-axis current is controlled as a function of the angle β (page 4, lines 10-16; Figure 3, reference number 24; page 5 lines 1-10; and the plot of Figure 5).

Claim 6 recites a method of controlling an electric motor (page 2, lines 7-9 and Figure 3) comprising: providing an electric motor having a wound stator, a rotor magnetically coupled to said wound stator, said rotor including surface mount permanent magnets (page 3, line 25 through page 4, line 2 and Figure 2, reference numbers 10, 12, 14, and 18); controlling q-axis current in the stator (page 4, lines 3-28 and Figure 3, reference numbers 24-36); controlling d-axis current in the stator (page 4, lines 3-28 and Figure 3, reference numbers 24-36); magnetically saturating the rotor; and wherein the step of controlling the q-axis current in the stator comprises controlling the q-axis current as a function of the angle β (page 4, lines 10-16 and Figure 3, reference number 24).

Claim 8 recites the method of Claim 6 wherein the step of controlling the d-axis current in the stator comprises controlling the d-axis current as a function of the angle β (page 4, lines 10-16 and Figure 3, reference number 24).

Claim 9 recites the method of Claim 6 further comprising the step of controlling the position of the electric motor (page 4, lines 25-28 and Figure 3, reference number 40).

Claim 10 recites a method of controlling an electric motor (page 2, lines 7-9 and Figure 3) comprising: providing an electric motor having a wound stator, a rotor magnetically coupled to said wound stator, said rotor including surface mount permanent magnets (page 3, line 25 through page 4, line 2 and Figure 2, reference numbers 10, 12, 14, and 18); providing a vector controller and voltage switched inverted to provide stator current to the wound stator (page 4, lines 3-28 and Figure 3, reference numbers 24-36); controlling the q-axis and d-axis current components of the stator current to control the torque of the electric motor and saturate the rotor magnetically (page 4, lines 10-15 and figure 3, reference number 24); and calculating the d-axis current setpoint as a function of the angle of the stator current vector with reference to the q-axis (page 4, lines 10-15 and figure 3, reference number 24).

Claim 11 recites the method of Claim 10 further comprising the step of determining the position of said rotor (page 4, lines 25-28 and Figure 3, reference number 40).

Claim 12 recites the method of Claim 11 further comprising the step of determining the actual current of the electric motor (page 4, lines 17-18 and Figure 3, reference number 38).

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Claims 1-6, and 8-12 stand rejected under 35 U.S.C. 103 as being unpatentable over U.S. Patent No. 6,378,367 to Iijima et al. in view of U.S. Patent No. 5,864,192 to Nagate et al.

VII. GROUPING OF CLAIMS

General Motors groups the claims as follows for this Appeal Claims 1-5 comprise a first group, Claim 6 comprises a second group, Claim 8 comprises a third group, Claim 9 comprises a fourth group, Claim 10 comprises a fifth group, Claim 11 comprises a sixth group, and Claim 12 comprises a seventh group. Group One patentably differs from groups one through seven, in that group one includes limitations for controlling the d-axis current as a function of the angle β. Group two patentably differs from groups one and three through seven, in that group two includes limitation for controlling the q-axis current as a function of the angle β. Group three patentably differs from Groups one, two, and four through seven, in that Group three includes limitations for controlling the q-axis and d-axis currents as a function of the angle β. Group four patentably differs from groups one through three and groups five through seven, in that group four includes limitations for controlling the position of the motor. Group five patentably differs from groups one through four and groups six and seven, in that group five includes method limitations for calculating the d-axis current setpoint as a function of the stator current vector with respect to the q-axis. Group six patentably differs from groups one through five, in that group five includes limitations for determining the

position of the rotor. Group seven patentably differs from groups one through six, in that group seven includes limitations for determining the current of the electric motor.

Groups one through seven do not stand or fall together and are patentably different.

VIII. ARGUMENT

A. THE SCOPE AND CONTENT OF THE PRIOR ART: CLAIM REJECTIONS UNDER 35 U.S.C §103

On page 2 of the Final Office Action of January 10, 2005, the Examiner rejected Claims 1-6, and 8-12 under 35 USC §103 as being unpatentable over Iijima et al., US 5,936,378 in view of Nagate et al., US 5,864,192.

1. Iijima et al.

a. Iijima et al. generally discloses a vector motor controller and drive unit for supplying power to the stator windings of a motor.

b. Iijima et al. does not teach or suggest controlling the d and/or q axis current components as a function of the angle β.

On page 4 of the Final Office Action, the Examiner stated that Iijima et al. does not expressly disclose a control block to control either the d or q axis current components as a function of β. Applicants respectfully agree with this statement. In column 1, lines 48-51, Iijima et al. expressly discloses that the d and q axis magnetizing components are equal and therefore the second term of equation 2 in Iijima et al. is zero. Iijima et al. is silent with respect to, and in fact teaches away from, controlling the d or q axis components as a function of β, as Iijima expressly assumes that the d and q (L_d and L_q) axis magnetizing components are zero. The present invention recognizes that at high stator current levels, when the effects of magnetic saturation cannot be neglected, the two magnetizing inductances will have different values where L_d is not equal to L_q. In the present case, the difference (L_d-L_q) is not zero, and additional torque can be obtained from the motor by controlling the d and q axis current components as a function of β.

c. Iijima et al. teaches away from controlling the d and/or q axis current components as a function of the angle β.

Iijima et al. is silent and in fact teaches away from controlling the d or q axis components as a function of β as Iijima et al. expressly assumes that the d and q (L_d and L_q) axis magnetizing components are zero. The present invention recognizes that at high stator current levels, when the effects of magnetic saturation cannot be neglected, the two magnetizing inductances can have different values where L_d is not equal to L_q. In these cased, the difference (L_d-L_q) is not zero, and additional torque can be obtained from the motor by controlling the d and q axis current components as a function of β.

2. Nagate et al.

a. In general Nagate et al. discloses a sensor to detect leaked magnetic flux.

b. Nagate et al. and Iijima et al., singly or in combination, do not teach or suggest the present claimed invention.

On page 3 of the Final Office Action, the Examiner stated that Nagate et al. discloses using rare earth magnets to cause magnetic saturation. Applicants assert that Nagate et al. is completely silent with respect to controlling the d and q axis current as a function of the angle β to generate magnetic saturation. Nagate et al. discloses the use of a Hall effect sensor 16 to detect a leakage of magnetic flux. The magnetic saturation in Nagate et al. is generated by inserting high energy magnets, not by controlling the d and q axis currents, as disclosed in column 16, lines 29-44. Accordingly, the combination suggested by the Examiner does not teach or suggest the present invention, and there would be no motivation to combine the Iijima et al and Nagate et al. references. Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching suggestion or incentive supporting the combination. *ACS Hospital Systems, Inc. v. Monteffore Hospital*, 732 F.2d 1572, 1577.

The Examiner by combining Iijima et al. and Nagate et al. is involved in improper speculation and conception of an invention based upon the cited prior art. In order to establish a prima facie case of obviousness, the Examiner must identify a suggestion or motivation to modify the teachings of the cited references to achieve the claimed invention. *In re Kotzab* 55 USPQ2d 1313, 1316-1317 (Fed. Cir. 2000). A critical step in analyzing the patentability of claims pursuant to section 103(a) is casting the mind back to the time of the invention to consider the thinking of one of ordinary skill in the art, guided only by the prior art references and the then-accepted wisdom in the field. Close adherence to this methodology is especially important in cases where the very ease with which the invention can be understood may prompt one "to fall victim to the insidious effect of hindsight syndrome wherein that which only the invention taught is used against its teacher." *In Re Kotzab*, 217 F.3d 1365. The Examiner has fallen victim to hindsight reconstruction and has also ignored the elements of the claimed invention and failed to explain how and why the claimed subject matter is rendered unpatentable over the prior art and point out where each of the specific limitations recited in the rejected claims is found in the prior art relied on.

c. *The suggested combination of Iijima et al. and Nagate et al. by the Examiner is improper.*

Iijima et al. is silent and in fact teaches away from controlling the d or q axis components as a function of β, as Iijima expressly assumes that the d and q (L_d and L_q) axis magnetizing components are zero, as previously discussed. The suggested combination of the Examiner is improper, references cannot be combined where the reference teaches away from their combination. See MPEP Section 2145.

SUMMARY

Iijima et al. and Nagate et al. singly or in combination do not teach or suggest the present claimed invention. Furthermore, the combinations suggest by the Examiner of Iijima et al. and Nagate et al. is improper. The Examiner has failed to explain how and why the claimed subject matter is rendered unpatentable over the prior art and point out where each of the specific limitations recited in the rejected claims is found in the prior art relied on. Applicants therefore request allowance of independent Claims 1-6, and 8-12.

Respectfully submitted,

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Appendix A

1. (previously presented) An electric motor control system comprising:

a stator for producing a magnetic field;

a surface mount permanent magnet rotor rotated by said magnetic field;

a motor shaft coupled to said rotor;

power electronics for controlling said magnetic field in said stator;

wherein said power electronics controls the q-axis and d-axis current components for the electric motor; and

a controller controlling said power electronics, said controller including a control block to control the d-axis current as a function of the angle β when said permanent magnet rotor is in magnetic saturation.

2. (original) The electric motor control system of Claim 1 wherein said stator includes current carrying coils to generate said magnetic field.

3. (original) The electric motor control system of Claim 1 wherein said surface mount permanent magnet rotor includes rare earth magnets.

4. (original) The electric motor control system of Claim 1 wherein said power electronics comprises a voltage source inverter.

5. (previously presented) The electric motor control system of Claim 1 wherein said permanent magnetic rotor exhibits non-linear behavior when said d-axis current is controlled as a function of the angle β.

6. (previously presented) A method of controlling an electric motor comprising:

providing an electric motor having a wound stator, a rotor magnetically coupled to said wound stator, said rotor including surface mount permanent magnets;

controlling q-axis current in the stator;

controlling d-axis current in the stator;

magnetically saturating the rotor; and

wherein the step of controlling the q-axis current in the stator comprises controlling the q-axis current as a function of the angle β.

7. (cancelled)

8. (original) The method of Claim 6 wherein the step of controlling the d-axis current in the stator comprises controlling the d-axis current as a function of the angle β.

9. (original) The method of Claim 6 further comprising the step of controlling the position of the electric motor.

10. (previously presented) A method of controlling an electric motor comprising:

providing an electric motor having a wound stator, a rotor magnetically coupled to said wound stator, said rotor including surface mount permanent magnets;

providing a vector controller and voltage switched inverted to provide stator current to the wound stator;

controlling the q-axis and d-axis current components of the stator current to control the torque of the electric motor and saturate the rotor magnetically; and

calculating the d-axis current setpoint as a function of the angle of the stator current vector with reference to the q-axis.

11. (original) The method of Claim 10 further comprising the step of determining the position of said rotor.

12. (original) The method of Claim 11 further comprising the step of determining the actual current of the electric motor.

13. (cancelled)

Evidence Appendix

There is no evidence entered and relied upon in this appeal

Related Proceedings Appendix

There are no proceedings related to this appeal.